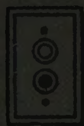
# FUNDAMENTALS OF HOUSE WIRING



WILLOUGHBY

# FUNDAMENTALS
*of*
# HOUSE WIRING

*By*
GEO. A. WILLOUGHBY
*Supervisor of Electrical Work,*
*Arthur Hill Trade School*
Saginaw, W. S., Mich.

THE MANUAL ARTS PRESS
Peoria, Illinois

*Printed in the United States of America*

# PREFACE

EXPERIENCE in attempting to locate text material suitable for presenting the fundamentals of house wiring to pupils in school and to others interested in work of this kind, and a desire to assist in promoting work of this nature have led me to write this book.

The value of the ability to make house-wiring installations, to understand what is back of a good electrical installation, to select good materials, and to appreciate the duties of an electrical worker is easily recognizable. People of various ages and in various walks of life need training along these lines.

The aim of this book is to present the fundamentals of house wiring in such a manner that the book may serve as a text for student use or, in some cases, as a reference book in this field.

The material contained in the book, together with that in the book *Electrical Conveniences in the Home* has provided the foundations of many interesting and valuable projects in planning, installation and maintenance. It is hoped that it may continue to be of value on a much larger scale.

In compiling this work frequent reference has been made to books on electrical work such as *The American Electricians' Handbook,* Croft's books, and others. Credit is due these for some of the information included. Assistance was afforded also by the Apple-

ton Electric Company, the Trumbull Electric Company, and others, by furnishing illustrations. To these and to George H. Fern, who assisted with some of the drawing, the author is indebted.

GEO. A. WILLOUGHBY.

# CONTENTS

# CHAPTER I

## Important Points to Consider

**1. Many Installations Are Inadequate.**—In the past, it has been customary to use various methods of wiring which served quite successfully, especially in the smaller residences, to provide only one main circuit from which other circuits were branched to the desired locations. This was at a time when lighting was the only common application of electricity in the home.

When one stops to consider the enormous strides in the advancement of electrical applications made within the past few years, as well as those being made at present, and brings to mind the fact that arrangements of this kind did not provide for flat-irons, electric toasters, hot plates, etc., it is evident that there is great need of many new considerations and requirements.

It is well, then, to consider several points of importance in order that we may become familiar with the possible dangers and with the requirements that are necessary for the proper provision and use of the many comparatively new electrical appliances available at the present time. This information is valuable to everyone who makes use of electrical appliances in the home, as well as to the person who makes provision for the appliances, and to those who sell them.

**2. Two Important Possible Dangers in Using Electricity.**—There are two important points which should be understood because they form the basis for the de-

termination of many of the important requirements for electrical installations, and they should be borne in mind when one is making an electrical installation or using electrical appliances:

1. Electrical circuits and appliances when not installed and used properly may be dangerous to life.
2. Electrical circuits and appliances when not installed and used properly may cause fire.

**3. How It Is Possible to Receive a Shock.**—First, let us understand that before one can receive a shock, he must make possible the flowing of electricity thru his body; that is, the body, or part of it, must form part of an electrical circuit. This may be brought about by touching the terminals at an electrical outlet or the bare wires in an electrical system. In large villages and cities where power is furnished by a power company it is usually carried under a high pressure which is reduced before the power is distributed. In such cases, it is sometimes possible to receive a shock, if defects exist, if one attempts to turn on a lamp at the socket while standing in a bath tub, while leaning against a gas stove or sink, while standing on a damp basement floor, or while in contact with any conducting material connected to the ground. Any possibility of this happening can be avoided by taking proper precautions.

**4. Fire Due to Defective Wiring.**—In a great many cases of fire, the cause has been traced to defective wiring or to the improper use of electrical appliances. The possibility of fire is due, of course, to the heating effect of electrical current, which we shall discuss

briefly. We are all familiar with the fact that electric-light bulbs get hot, and perhaps some are familiar with the fact that whenever electricity flows thru a conductor some heat is caused. The amount of heat may be small, however, and in many cases it is unnoticeable.

**5. Things Affecting the Amount of Heat.**—The amount of heat generated when an electric current flows thru a conductor depends upon the resistance of the conductor and upon the current flowing thru it. The resistance depends upon the size of the wire, its length, and the material of which it is made. The facts that the amount of heat depends upon the size of the wire and the current flowing thru it are of very great importance.

**6. Heat Varies as the Square of the Current.**—It is especially important that one understand that the heat increases very rapidly as the current is increased. The fact is that the heat increases directly as the *square of the number of amperes*. That is, if, when a flat-iron drawing 5 amperes is connected to a line, a certain amount of heat is caused in the wires carrying the current to it, *four times as much heat would be caused by two of the same kind, or anything drawing 10 amperes*. If three times as many amperes were drawn, the heat would be nine times as much, and if four times as many amperes were drawn sixteen times as much heat would be generated.

**7. Heat Varies with the Size of Wire.**—The resistance of a copper wire, the kind commonly used in house wiring, depends upon the area and the length. The area of a circle equals 3.1416×*diam. squared divided*

*by 4.* Thus the areas of wires vary as the squares of their diameters. The larger the wire, then, the less is going to be the resistance per foot and the less the resistance per foot, the less will be the heat generated when an electric current passes thru the wire. A copper wire having a cross-sectional area of 1/10 of a square inch will have twice as much resistance per foot as one having an area of 2/10 of a square inch. It will be seen, then, that the size of the wire has considerable to do with the amount of heat generated when current flows thru it and that wire sizes in an electrical installation are important.

**8. Possible Accidents.**—From a study of the foregoing it will be seen that it is exceedingly important that proper precautions be taken to avoid possible accidents which may be caused in many ways, including the following:

1. A bare wire may be the cause of a shock.
2. Defective insulation may cause bare spots on wires.
3. Poor connections in fixtures may cause contact of wires with the metallic parts of the fixture and cause a shock.
4. Wires that are too small may be forced to carry so large a current that they get hot enough to start a fire.
5. Defective joints may cause arcing which may cause fire.
6. Heating devices left turned on too long may cause fire.
7. Using a heating device on a lighting circuit may cause fire, or other trouble.

8. Overloading a motor may cause fire.
9. Short circuits may cause fire.
10. A poor entrance arrangement may be dangerous.

**9. Danger of Bare Wire.**—It is obvious that bare wires for installations in homes would be very dangerous. One trying to use electricity would have untold difficulty in trying to keep from touching them as well as in trying to keep them apart to avoid short circuits. It is very evident, then, that wire with a good insulating covering should be used.

**10. Defective Insulation.**—Defective insulation is practically the equivalent of having a bare wire and the results are just as disastrous as bare wires would be in many cases. Hence any defects in insulation should be avoided or repaired.

**11. Poor Connections in Fixtures.**—If connections in fixtures, especially in metallic sockets, are not made properly and any possible connection is brought about between wires and the metallic shell, there is always the possibility of danger.

**12. Danger in Using Wire That Is Too Small.**—From the foregoing it can be readily understood that the wire used for furnishing electrical current to various appliances should be sufficiently large. If the wires are too small there is the possibility that they will become so hot that the insulation will be burned off, and perhaps some combustible material ignited.

**13. Danger of Defective Joints.**—If joints in wires are poor, there is a possibility that the electricity will "arc" over the open spaces between the wires and cause enough heat to set fire to anything combustible with which the wire may come in contact. Then, too,

the resistance of a poor joint may be sufficient to cause it to get hot or to cause difficulty in forcing electrical current thru it.

**14. Dangers in Using Heating Appliances.**—Heating appliances may cause fire if they are left with the current turned on and an excessive amount of heat is generated. This is especially true of electric flat-irons. Many fires have been caused by leaving an electric flat-iron turned on.

**15. Danger in Using Lighting Circuits for Heaters.**—It is often dangerous to connect a heater to a lighting circuit. This will be readily understood when we consider that an electric heater requires much more current than electric lamps in most cases. The average lamp draws about 1/2 an ampere while the average flat-iron draws about 5 amperes or ten times as large a current. Now, applying the rule that the heat generated in a circuit varies as the square of the current we see that in a case where a flat-iron is connected to a lamp circuit the heat generated in the wires leading to the outlet would be 10×10, or 100 times as much as when one lamp is being used. In fixtures where small wires and several joints may be found, it is evident that the possibility of danger is increased.

**16. Danger in Overloading a Motor.**—The harder a motor is forced to work, the more current it draws from the line to which it is attached. This is obvious when we stop to consider that power delivered by a motor could not possibly exceed that taken from the electric line and that the power taken from the line varies as the product of the voltage and the amperage. The voltage being constant, the number of amperes

drawn must increase as the load on the motor is increased.

It is possible, then, that by overloading a motor such a heavy current may be drawn from the line that excessive heating is caused.

It should be borne in mind also that more current is drawn by a motor when it is started than after it attains its running speed, and that if it does not start quickly and easily there is danger of overheating.

Overloading may be due sometimes to a lack of lubrication or, especially in the vacuum cleaner, to the clogging of the fan or the wrapping of hairs or threads around the motor shaft.

**17. Short Circuits May Cause Fire.**—When a short circuit is formed, a heavy current flows thru the wires of the line because of the lessening of the resistance. Just what the number of amperes might be cannot be determined, but it would be exceedingly large. In such a case it is obvious that excessive heating of the wires would be brought about almost immediately if some protection were not provided. It is one of the functions of fuses or circuit breakers to open the circuit when such an accident takes place.

**18. Poor Entrance Arrangements May Be Dangerous.**—The entrance is the place at which the power lines enter the home and it is one of the most important parts of an installation. It is at this point that the fuses are often located and the service switch and fuse blocks are often placed in the basement, one of the most dangerous parts of the house. Coming in contact with one of the power wires while standing on a damp basement floor is dangerous.

Since the fuses are usually located at the entrance, and it is quite common for the layman to replace fuses when they blow, it is exceedingly important that the arrangement be such that this can be done without danger. Careful consideration should be given this part of an installation.

### Summary of Chapter I

1. Some electrical installations are inadequate.

2. Electricity when not properly used may be dangerous to life or it may cause fire.

3. Heat is generated when electricity flows thru a wire.

4. The heat caused by an electric current varies with the resistance of the wire in the circuit and the square of the number of amperes.

5. Accidents may be due to: (1) bare wire, (2) defective insulation, (3) poor connections, (4) the use of wires that are too small, (5) defective joints, (6) heating devices left turned on, (7) overloading a motor, (8) short circuits, or (9) poor entrance arrangements.

### Questions

1. How do you account for the fact that many electrical installations are inadequate?

2. What two important possible dangers may be involved in the improper use of electricity?

3. How is it possible for one to receive a shock?

4. How may defective wiring cause fire?

5. Upon what does the heating of a wire depend?

6. Make a list of possible accidents in the use of electricity.

7. Explain why the wires of a circuit must be sufficiently large.

8. Why are defective joints dangerous?

9. What precautions must be taken when using heating appliances?

10. How may overloading a motor cause fire?

11. Why must protection be provided in case of short circuits?

12. Why is the entrance arrangement important?

## CHAPTER II

### Suggestions for Safe Installations

**19. Rules and Suggestions for Wiring.**—Because of the extensive use of electricity in the home and the possible dangers due to improper installations and improper use of electrical appliances, various organizations, after investigation and experiment, have laid down certain rules and regulations which are to be observed during the construction and maintenance of electrical systems and apparatus. Among these are the National Board of Underwriters, the American Institute of Electrical Engineers, the National Electric Light Association, and other bodies electrically interested. Many of our larger cities thru their electrical inspection departments are considering the electrical problems very carefully and are eliminating certain types of work in specified districts. In some cases certain types of installations, certain entrance arrangements, etc., are required by city ordinances.

**20. The National Electrical Code or Underwriters' Rules.**—The National Electrical Code comprises a set of rules drawn up and published by the National Board of Fire Underwriters to assist in holding up certain requirements and electric wiring regulations. The code has of itself no legal force but merely contains the rules and requirements of the National Board of Fire Underwriters. These regulations are used as a basis for most electrical work, however, and in some cities are given a legal status. These rules and regu-

lations are modified and new editions published every two years.

**21. Local Requirements.**—In addition to the Underwriters' rules which are intended to assist in making electrical installations safe, we find that in many cities local legalized requirements must be met. Local requirements take precedence over the Code rules.

One should be familiar with both national and local requirements, for these are intended to assist in making impossible any of the dangers referred to in the preceding chapter.

**22. Select the Best Type of Wiring.**—It is obvious that both convenience and safety should be considered when selecting the type of wiring to be used. Selections should be made not only to satisfy requirements alone, but to insure the best results. It is estimated that 5 per cent of the building cost may well be invested in the electrical installation. The electrical installation in a home will afford years of comfort and convenience. One should not just look at the price, but investigate, compare, consider what one is getting for his money. One should be sure to have everything right so that no part will have to be done over.

**23. Provide Many Safe Convenience Outlets.**—Convenience outlets placed unsparingly in a home will add to the comfort and will give a flexibility that will permit of frequent re-arrangement of furniture which is so desirable. Then, too, they will provide outlets for the various appliances at points near the places at which they are to be used and thus eliminate the dangers and inconveniences involved in the use of exceedingly long and ill-placed extension cords.

When selecting the type of receptacle to be used at a convenience outlet, consider the danger side of the question and provide such types as will guard against possible injury to children or others not familiar with electrical applications.

**24. Make the Main Wires Large Enough.**—Remember that wires should be large enough to carry safely all of the current required in the future as well as at the present. Make the main wires large enough to take care of this future demand.

**25. Don't Overload Circuits.**—Recommendations set forth by the Underwriters include those covering the protection of circuits against overload. In general, not more than 660 watts are permitted on a single circuit. That is, a separate set of fuses must be provided for each circuit carrying a load of 660 watts or less. Be sure to provide plenty of fuses.

**26. Use Proper Fuses.**—The fuses required in a 660-watt circuit where the voltage is 110 are of 6-ampere capacity. In some cases, however, 10-ampere fuses are permitted and provide safety. Fuses are for the purpose of protection. Use the proper size.

**27. Avoid Exposed Circuits and Terminals.**—It is obvious that exposed circuits and terminals are a menace, especially in the home, and should be avoided.

**28. Use Good Materials.**—There are various kinds and grades of materials on the market for use in electrical installations. The characteristics of these materials should be known and those of the best quality and safest construction should be selected.

**29. Select a Safe Entrance Arrangement.**—Since, as has been stated before, the entrance arrangement is of

great importance, it is obvious that it should be such that fuses may be replaced with utmost safety. The selection of such an arrangement should be given careful consideration.

### Summary of Chapter II

1. The National Electrical Code is a set of rules relative to good electrical installations.

2. Local wiring requirements have been set up in many places as an aid in bringing about the proper use of electricity.

3. The most suitable type of wiring should be used in every electrical installation.

4. A sufficient number of properly located convenience outlets should be provided.

5. The main wires should be large enough to eliminate the possibility of overheating.

6. The circuits should be arranged so they will not be overloaded.

7. Proper fuses should be used.

8. Exposed circuits and terminals should be avoided.

9. Good materials should be selected.

10. A safe entrance arrangement should be provided.

### Questions

1. Why are rules and suggestions for wiring desirable?

2. What is the National Electrical Code?

3. What is meant by "local requirements"?

4. What should be taken into consideration when one is selecting the type of wiring to be used in a given house?

5. Why must the size of the main wires be taken into consideration?

6. How many watts load is ordinarily permitted on a single circuit?

7. Why is there a limit to this?

8. Why is it important that fuses of the correct capacity be used?

9. What is the desirable capacity of fuses for a common circuit?

10. Why should exposed circuits and terminals be avoided?

# CHAPTER III

## Service Arrangements and Cabinets

**30. Importance of the Service Arrangement.**—The importance of providing a safe and convenient service arrangement cannot be overestimated. At the entrance, where it is very common to locate the meter, service switch, and cut-outs, perhaps the greatest liability to danger exists because these are so often placed in the basement. With an arrangement of this kind in the basement there is the possibility of coming into contact with the line wires when replacing fuses as one is on the basement floor which is in close contact with the ground, and often damp. A brief study of service arrangements is, therefore, of great importance not only to the one making the installation, but also to the one who makes use of it.


Fig. 1. A simple entrance, or service switch—a fused switch.

**31. Simple Entrance or Service Switch.**—In Fig. 1 is shown a simple service switch that has been used quite extensively in the smaller installations, but which, as shown, is at the present time not permitted by the Underwriters. The switch has usually been mounted on the wall or on a meter board with the line wires running directly to the upper terminals, thru the fuses and the switch, thru the meter, and then to the circuit, feeding the branch circuits in the house. With such an arrangement the opening of the switch

does not disconnect the fuses, it simply disconnects the circuits in the house. It will be seen, then, that the line wires are connected directly to the lower parts of the fuse receptacles at all times. Then, too, there is the possibility of coming into contact with the blades of the switch.

In more extensive installations, switches of this type have been used with cut-outs such as shown in Fig. 2, inserted into the various circuits, these cut-outs being placed in many cases on the meter board near the service switch. With such an arrangement, the opening of the switch will disconnect the cut-outs from the line and fuses can be replaced without danger. There still remains the possibility of coming into contact with the upper switch terminals or wires.

FIG. 2. A two-wire, plug fuse, cut-out.

**32. Entrance of the Service Wires.**—In simple installations, it has been customary to bring the entrance wires thru the side of the house and directly to the meter, porcelain tubes being used as bushings where the wires passed thru the wood. In most modern installations, however, the service wires are run in conduit regardless of the type of wiring within the house. These runs of conduit, on the outside of the house, are in many cases bent at the top where the wires enter and at the bottom where they enter the house. The fittings shown in Figs. 3 and 4 are very convenient for this, however, and are used extensively at the present time. The upper fitting keeps rain from getting into the conduit and the lower one provides the right-angle turn without requiring the space necessary

for a bend. This is especially convenient where the entrance conduit is on the side of a house adjacent to a

FIG. 3. A special conduit fitting for an entrance or service arrangement.



FIG. 4. A special water-tight conduit fitting suitable for an entrance arrangement.

sidewalk. The fitting is provided with a water-tight cover to prevent water from getting into the conduit.

**33. A Simple Enclosed Service Switch.**—In some places the danger involved in the use of an open entrance switch has been eliminated by the use of a steel box such as shown in Fig. 5. Such an arrangement eliminates the constantly exposed switch and fuses, but to open the switch requires the opening of the box. In other similar installations the cut-outs as well as the service switch have been placed in steel boxes to afford protection.

FIG. 5. A special fitting for a knife switch.

In cases where such arrangements are used and the wires leading from the boxes are not run in steel conduit, porcelain bushings such as shown in Fig. 6 are inserted in the knock-outs provided and the wires are passed

thru them. The ring shown in Fig. 7 is used for holding the bushing in place.

**34. Enclosed, Externally Operated Service Switches.**—To eliminate all danger to the layman in the replac-

FIG. 6. A porcelain bushing for use where wires pass into a metallic box or fitting, thru knock-outs.

FIG. 7. The ring for holding porcelain bushings in place.

ing of fuses it is recommended by the Underwriters that entrance switches be both enclosed and externally operated, in which case it is impossible to come into contact with the switch blades and it is possible to open the switch conveniently.

To fulfill these requirements several types of switches have been devised which are very satisfactory. The one shown in Fig. 8 is very convenient, neat appearing, and satisfactory. In installations of this kind, in small houses, it is quite customary to place sign receptacles for the fuses in the lower part of the switch box and connect them in the circuit. Larger fuses are then placed in the switch cut-out than are required and the fuses of smaller capacity are placed in the sign receptacles. The switch box is then closed and sealed. If a short circuit is formed, or a circuit is overloaded in any way the fuses in the sign receptacles blow. They can be replaced with absolute safety, without opening the switch box, by simply opening the switch, by pulling the lever on the outside, which disconnects them from the line.

To provide a more convenient arrangement than the application of sign receptacles for holding the fuses, a special porcelain receptacle has been devised which is attached as shown in Fig. 8. The advantages of this are obvious.

FIG. 8. An enclosed, externally operated entrance or service switch, with meter and special external fuse holder attached.

**35. Service Arrangements in Large Installations.**—In larger installations many circuits may be required and in some cases several different meters may be used which involve the use of large service switches. In such cases it is not uncommon to find arrangements involving the use of fuse cabinets or other additional equipment. These will be taken up briefly.

**36. Cabinets and Panels.**—In many of the larger installations it is desirable to have the branch circuits lead from a point located near the center of the system or from a point other than at the entrance. In such cases it is customary to use a distributing panel

on which the cut-outs are provided. The panels are placed in cabinets such as shown in Figs. 9 and 10. Cabinets are made in a variety of forms and some are

FIG. 9. A single-door cabinet.

FIG. 10. A door-within-a-door cabinet.

provided with open switches while others are what are commonly termed "safety cabinets" in which the switches and fuses are enclosed.

**37. Large Service Switches.**—In larger installations or in installations where electrical appliances are used very extensively, it is customary to run three wires of what is known as a three-wire system of distribution instead of only two of the three as is done in a large number of cases. A three-pole switch is used in such an installation. See Fig. 11.

FIG. 11. A three-pole, enclosed, externally operated switch.

**38. Methods of Installing Service Arrangements.**—In Fig. 12 are shown several satisfactory methods of

installing service arrangements. At *1* is shown a large three-pole switch, the wires leading downward from it being ground wires. At *2* is shown an arrangement where a short run of rigid conduit, provided with suitable fittings, leads to a fuse block

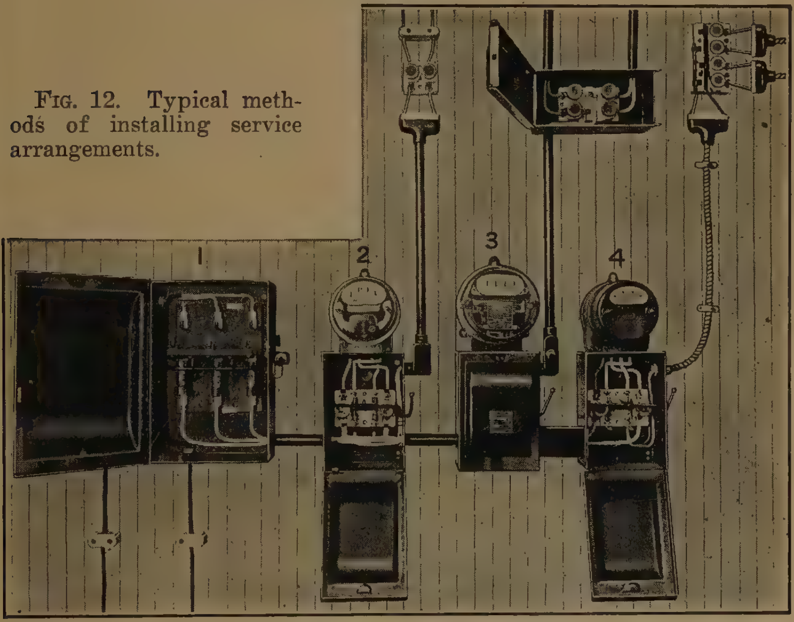



FIG. 12. Typical methods of installing service arrangements.

from which wires are held by porcelain cleats. At *3* a neat conduit installation is shown in which the cutouts for two distinct circuits are enclosed in a steel box from which conduit runs are made to the outlets. At *4* an installation involving the use of flexible steel conduit is shown in which two open fuse blocks are provided which provide cut-outs for the two circuits inclosed in flexible conduit.

In Fig. 13 is shown a phantom view of an installation showing a very neat installation for concealed work which involves the use of a special meter terminal fitting.

FIG. 13. A phantom view of an installation showing a knock-out box with a special meter terminal fitting and meter mounted. The box is flush with the front of the cabinet.

## SUMMARY OF CHAPTER III

1. A safe and convenient service arrangement is especially desirable.

2. An open service switch is not entirely satisfactory because of its exposed terminals.

3. Entrance, or service wires in conduit are most satisfactory, altho in some cases the knob-and-tube method has been used.

4. In some cases service switches have been placed in boxes.

5. The most satisfactory service switch is one of the enclosed, externally operated type.

6. In large installations where there are several circuits, panels placed in cabinets are commonly used.

7. In some cases three service wires are run into the house and a three-pole switch is used.

8. There are several satisfactory entrance arrangements.

### Questions

1. Why is the entrance, or service, arrangement important?
2. What are the disadvantages of the simple service switch?
3. How have these disadvantages been overcome in later types of switches?
4. How has the simple knob-and-tube entrance been provided?
5. Why is a conduit entrance desirable?
6. What is the advantage of having cut-outs in addition to those in the service switch?
7. What is a panel? A cabinet?
8. Make a sketch showing the various methods of arranging the service switch and cut-outs.

# CHAPTER IV

## Wiring New Buildings—Knob-and-Tube Method

**39. Where Knob-and-Tube Wiring Is Used.**—Concealed knob-and-tube wiring is used very extensively in frame house work and will probably continue to be popular for many years to come because of the ease with which it is installed, and its cheapness. Modifications of this method are required in some cities, and in some few cases it is prohibited entirely. Nevertheless, the work is very important and should be understood by every electrical worker.

**40. When the Wires Are Installed.**—The wires are run just after the floors and studs are in place and before the lathing is done. This part of the work comprises the installing of the mains, the branches, the taps and the outlets.

**41. When the Job Is Completed.**—The completing of the job, comprising the installation of the entrance switch, the fixtures, the meter-board, etc., is done after the building is otherwise completed.

**42. Rules Relative to Knob-and-Tube Installations.**—There are several rules set forth recommending methods of installation included in the Underwriters' Code. Then, in addition to these, many cities have ordinances governing the installation of electrical wiring and apparatus. The Underwriters' rules form the basis for most of these, however, so we shall study how the work should be done to comply with those specified in the Code. Then, in most cases, it will be very easy

to fulfil the necessary requirements to comply with city regulations. It is not desirable to give the complete set of Underwriters' rules just as they are written, so for our purpose we shall simply give methods of installing wiring which are in accord with them.

**43. Problems Involved in Wiring a New House.**—When installing the wires in a new building using the knob-and-tube method, many different problems arise in practically every case with which the worker should be thoroly familiar. Among the most common of these are:

1. The making of horizontal runs along the joists.
2. The making of horizontal runs across the joists.
3. The making of vertical runs between studs.
4. The making of runs thru floors.
5. The provision of ceiling outlets.
6. The provision of wall-fixture outlets.
7. The provision of receptacle outlets.
8. The provision of snap switch outlets.
9. The provision of flush switch outlets.
10. The crossing of wires properly.
11. The crossing of water and gas pipes properly.

**44. Horizontal Runs Along Joists.**—The joists in a house are the timbers to which the floors and ceilings are attached. They are usually 1⅝″ thick and from 4″ to 10″ wide and are placed on edge to support the floors placed upon them. Upon their under edges are placed the lathing and plaster which form the ceiling.

It is evident that in wiring a house there will be many cases when it will be necessary to run the wires in the direction of these timbers. The fact is that the

more of the wiring that can be run in this manner the better, in so far as the ease of installing is concerned.

**45. Hints of Importance for Running Wires Along Joists.**—There are several points of importance which should be borne in mind while making a wiring run between joists which include the following:

1. The wires must be supported on porcelain knobs which will hold them at least 1″ from a surface of any kind.
2. The wires should be run on separate joists where possible.
3. In case it becomes necessary to run two or more wires on a single joist, they must be kept at least 5″ apart.
4. Knobs must be placed along the wires at intervals of not more than 4½ feet and they should be placed at the beginning and end of every run. Plenty of knobs should be used if they are necessary and in many cases it may be advisable to place them only 2½ or 3 feet apart if there is any chance for the wiring to be interfered with as might be the case in a basement or attic.
5. The wires should be placed far enough from the top of the joists to leave a space of at least 1″ between them and the floor.
6. The wires should be placed far enough up from the bottom of the joists to leave a space of at least 1″ between them and the ceiling.
7. The wires should be drawn taut so they will not sag.

8. They must be placed in the knobs properly so the insulation will not be cut or injured.
9. The knobs should be fastened to the timbers securely so they will support the wires rigidly.

**46. Horizontal Runs Across Joists.**—It is evident that there will be many cases in the wiring of a house where it will be impossible to run wires lengthwise of the joists. In these cases the wires must be carried at right angles to them or, in other words, across them.

The following rules should be observed when doing this work:

1. The wires must pass thru the joists and not be supported on top of them.
2. Wires passing thru joists must be insulated from them by porcelain tubes.
3. Insulating tubes should always extend from ½″ to ¾″ on both sides of the joist.
4. Tubes should not extend more than ¾″ beyond the edges of the joists because of the liability to breakage.
5. The holes bored in the timbers must be at least 5″ apart and of such size that they will just permit the passing of the tubes thru them.
6. It is usually considered best, and it is frequently more convenient, to bore the holes thru the joists slanting instead of on a horizontal line.
7. In placing the tubes in the holes in the joists, the heads should be at the higher level so they will drop into place and remain there, except at turns made in runs changing from a direction along the joists to one across them. In

such cases a knob is used at the turn and the tube is placed so the pull on the wire will have a tendency to pull the tube into place.

8. In many cases where the holes are bored thru the joists on a slant it is well simply to place the tubes on the wires as they are drawn thru the holes and to put them into place after the ends of the wires have been knobbed. The wires need not be drawn taut in this case as they are run for they are drawn so when the tubes are put into place.
9. In cases where two joists are found together and a tube is not long enough to reach thru them, or one the proper length is not available, it is usually permissible to use a piece of circular loom the proper length.

**47. Vertical Runs Between Studs.**—The studs in a house are the vertical timbers which form the inner part of the walls and partitions. It is upon these that the lath and plaster, forming the side walls of the room, are placed. In the house of average size they are usually two-by-fours placed 16″ apart.

Switches, wall outlets, baseboard outlets and floor outlets usually require the running of wires in the partitions and walls, so it can readily be seen that in wiring a house many occasions will arise which will require the running of wires between these studs.

When doing this work, the rules regarding the installation of wires between joists should be borne in mind. In addition to the points brought out in this regard, it should be observed that since the studs are usually only 4″ wide it is impossible to place more than

one wire on each. In case it becomes necessary to run more than two wires between two studs, wooden cleats should be installed at intervals of not more than 4½ ft. and the wires supported on them. See Fig. 14. The wires must be at least 5″ apart in a run of this kind. The cleats must be placed between the studs in such a way that the wires will be at least 1″ from the lath and plaster on the finished wall.

**48. Runs Thru Floors.**—In running wires from a room to another above it is necessary to pass the wires


Fig. 14. A sketch of a vertical run between studs where three wires are supported on porcelain knobs nailed to wooden cleats.

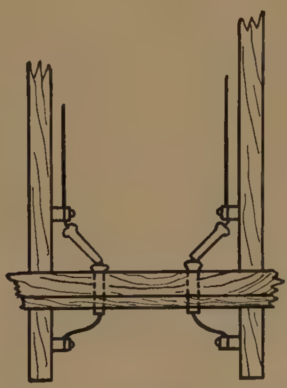


Fig. 15. A sketch showing a run thru a floor where additional tubes are used to protect against plaster droppings.

thru the floor in many cases. When doing this it should be remembered that extra tubes, one on each wire, must be placed on the wires in addition to the two tubes passing thru the floor. See Fig. 15. The

purpose of these tubes is to protect the wires against plaster droppings. Sometimes it is permissible to use circular loom if suitable tubes cannot be procured for this work.

**49. Provision of a Ceiling Outlet.**—As has been stated before provision must be made in new houses before they are finished for the installation of fixtures after the house is otherwise completed. At the stage in the building of the house when the wiring is installed the ceilings and walls are open. To provide for a ceiling fixture, a cleat, a piece of board at least $\frac{7}{8}''$ thick and $6''$ or $7''$ wide is nailed between the joists in the manner indicated on the sketch in Fig. 16. This cleat should be placed about $\frac{3}{8}''$ above the lower part of the joists to allow space between the lathing and the cleat for the plaster to grip.

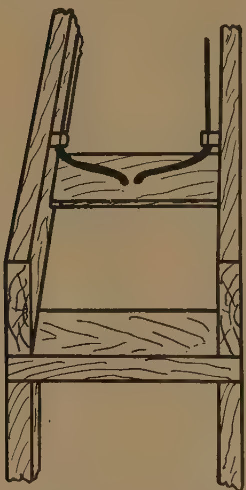


FIG. 16. A sketch showing a ceiling outlet provided for with a wooden cleat. Loom encircles the wires from the last knobs.

Two holes should be bored in the cleat where the fixture is to be located. These holes should be as near each other as possible and large enough to permit the passing of circular loom thru them.

Loom must encircle the wires from the last knob, thru the cleat a distance great enough to reach thru the finished ceiling.

The wires encircled by the loom should be long enough to extend six or seven inches below the finished

ceiling. The loom covering on the wires is indicated on the sketch in Fig. 16.

**50. Provision of a Wall-Fixture Outlet.**—Many times fixtures are attached to the walls; so it is necessary to know how to provide for such installations. This is done in a manner very much similar to that in which provision is made for a ceiling outlet, the only important difference being that the cleat and wires are between studs instead of between joists. Such an arrangement is shown in Fig. 17.

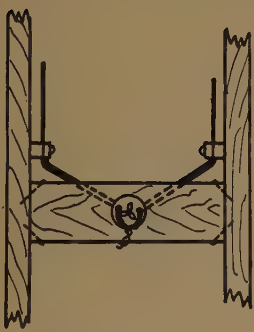


FIG. 17. A sketch showing the provision for a wall bracket. Loom encircles the wires from the last knobs.

With this arrangement as well as with the ceiling outlet it is well to use an outlet box such as shown in Fig. 18. This box is placed on the cleat as indicated in Fig. 17 and provides a very satisfactory enclosure for the joints where the wires in the fixture are connected to those coming into the box.


FIG. 18. A loom box.

**51. Provision of a Receptacle Outlet.**—Because of the very extensive use of portable electrical appliances it is evident that many receptacles should be provided and the wireman must arrange for the installation of these.

Flush receptacles must always be placed in steel boxes such as shown in Fig. 19. To support this box properly wooden cleats are used as shown in Fig. 20.

If the receptacle is to come in the wall above the base-board, the cleats should be set back about 3/8" to give the plaster a chance to grip.

When receptacles are to be placed in base-boards it is well to confer with the carpenter as to the best method of providing for them. Sometimes it is desirable simply to run wires down where

FIG. 19. Steel box in which flush receptacle or flush switch is placed.

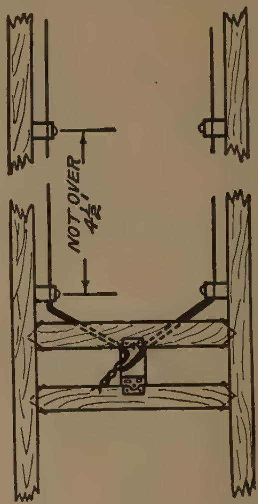



FIG. 20. A sketch showing the method of providing for a flush receptacle or a flush switch.

the receptacle box is to be located and to have the men bring them thru holes in the base-boards as they are put into place. The electrician can then cut the holes in the boards at just the right places and install the boxes at the time he installs the receptacles.

**52. Provision of a Snap-Switch Outlet.**—Snap switches are surface switches. That is, they are attached to the surface of the wall and not hidden within it. All that is required in providing for such a switch is the placing of a wooden cleat about 7/8" thick, and wide enough to hold the loom in place and to provide

a support for the screws that hold the switch in place. See Figs. 21 and 22.

The cleat is usually placed so the switch will be four feet above the floor unless otherwise specified.

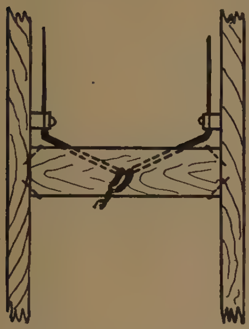


FIG. 21. A sketch showing a method of providing for a surface snap switch such as shown in Fig. 22.

FIG. 22. A surface snap switch with the cover removed.

**53. Provision of a Flush-Switch Outlet.**—A flush switch is one which is placed within the wall and covered with a plate. The switch is always placed in a steel box such as shown in Fig. 19, and arrangements for its support are made in the same manner as for a flush receptacle shown in Fig. 20.

**54. Crossing Wires.**—When it becomes necessary to cross wires, as is very often the case, the following requirement must be taken into consideration: Wires must not come nearer than 2″ from any other wire without being permanently separated from it with a firmly fixed non-conductor.

To fulfil this requirement, it is customary to place a porcelain tube on the wire and to secure it in place by taping its ends to the wire. It is claimed by some that this is not entirely satisfactory because the tape

gradually becomes dry and after a considerable length of time becomes loose. Many wiremen clamp short pieces of wire at each of the ends of the tube to hold it in place. The safest method of securing the tube in place, however, is to place a knob at each end if this is possible.

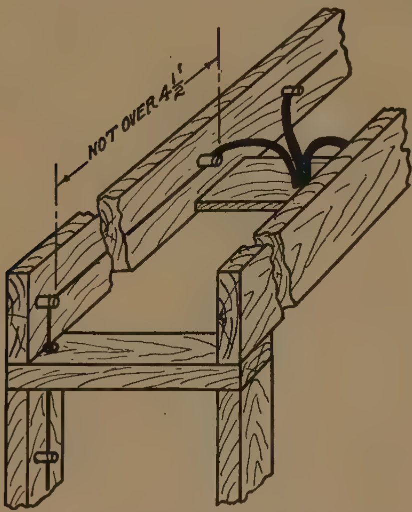



Fig. 23. A sketch showing a ceiling outlet where the "loop method" is used. All wires are looped from outlet to outlet, as in conduit work, making all joints accessible.

**55. Crossing Water or Gas Pipes.**—Sometimes it is necessary in the installing of wires to cross metallic pipes. Special precautions should be taken when this is necessary to prevent the wires from coming into contact with the pipes. In most cases it is sufficient to place a porcelain tube or piece of loom on a wire where it crosses the pipe. Either of these must be prevented from slipping by some suitable arrangement. Where wires must cross pipes in a damp place it is not advisable to use loom. It is well, if possible, to keep the wires at least 2″ away from the pipes. It is always best to run wires over pipes rather than under them to do away with the possibility of the covering becoming water-soaked by the dropping of the water which accumulates on the pipes.

**56. The Loop System of Wiring.**—As has been stated before, the knob-and-tube method is commonly used, that is, where the wires are supported on knobs and run thru tubes and the wires running to the branches are tapped onto the main wires at the most convenient points. The chief objections to this method raised by some are that the joints made before the building is finished are concealed and are not accessible after the work has been completed, and that there is considerable danger of fire, especially if the circuits are overloaded and not properly protected.

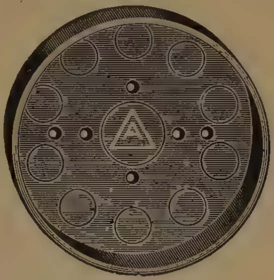


FIG. 24. A loom box especially adapted for use where the loop method of wiring is used.

These objections can be overcome quite readily by the use of what is called the "loop system" of wiring. This differs from the old method in that no connections or joints of any kind are made except at outlets and that at all outlets where more than two wires are brought out, and sometimes when only two are brought out, are provided with steel boxes or plates which form fire-proof enclosures for the joints. Fig. 23 shows an arrangement where the loop system is used, three wires passing thru the cleat between the joints, and in Fig. 24 is shown a typical loom box. It is evident that all connections are accessible at all times when this system is used.

When installing wires using this method, an excessive number of wires may come into a single outlet if due consideration is not given to the routing of the

conductors. If it is borne in mind that it is possible to have only three wires coming into outlet boxes if one of the feed wires is run to fixture outlets and the other to all of the switch outlets and outlets where

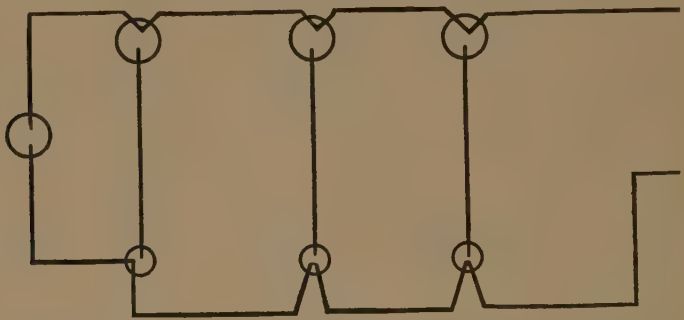


FIG. 25. A sketch showing how it is possible to have not more than three wires in an outlet where the loop method is used. The small circles represent switch openings and the large ones fixture openings.

the fixtures are to be connected directly to the feed wires, and if this is applied wherever possible, the number of wires in one outlet will not be excessive. See Fig. 25. Other advantages of this method are obvious.

## SUMMARY OF CHAPTER IV

1. Knob-and-tube wiring is used extensively because of its cheapness.

2. The wires are installed in a new house after the floors and studs are in place and before the lathing is done.

3. Rules relative to knob-and-tube wiring are included in the National Electrical Code.

4. Knob-and-tube wiring involves the making of wire runs on knobs and thru tubes and the provision of various outlets for electric fixtures.

5. Certain precautions must be taken when running wires along joists; when running wires across joists; when making runs between studs; when making runs thru floors; and when providing outlets of various kinds.

6. Wires and gas or water pipes must be crossed by wires in a desirable manner.

7. The "loop system" of knob-and-tube wiring is one in which no connections are made except at outlets.

### Questions

1. Where is knob-and-tube wiring commonly used?
2. Give a brief description of this method.
3. What are its advantages?
4. Is this type of wiring permitted in your community?
5. What are the rules relative to the making of horizontal runs of wire along joists?
6. What are the rules relative to the making of horizontal runs across joists.
7. What are the rules relative to the running of wires between studs?
8. How are runs thru floors made?
9. What is the purpose of the steel box in which receptacles and switches are placed?
10. How is provision made for a ceiling fixture?
11. How is a flush switch provided for?
12. How is a snap switch outlet provided?
13. Why should cleats be set back from the surface of the joists or studs?
14. Where is loom used?
15. What is a gang switch box?
16. What should be done when wires cross?
17. How should water or gas pipes be crossed?
18. What do you understand is meant by the "loop system"?
19. What are some of the advantages of this system?
20. How is it possible to avoid an excessive number of wires at outlets when this method is used?

## CHAPTER V

### Conduit and Armored Cable Work

**57. Applications of Rigid Conduit.**—Rigid conduit wiring is approved for both concealed and exposed work and for use in nearly all classes of buildings. For ordinary conditions, wiring in iron conduit is probably the best, altho it is the most expensive.

As a general proposition, conduit wiring should be used wherever the job will stand the cost. Ordinances in some cities now require that all concealed wiring be in conduit and in others that it shall be the only accepted method in certain sections. It is probable, because of its inherent advantages, that this method will grow in popularity and will ultimately be almost universally used. Iron conduit effectively protects the conductors and provides a smooth race-way permitting the ready insertion or removal of conductors.

**58. Advantages of Iron Conduit.**—The advantages of iron conduit are:

1. It is fire proof.
2. It is moisture proof.
3. It is strong enough mechanically so nails cannot be driven thru it.
4. It is not readily deformed.

**59. What Rigid Conduit Is.**—Rigid conduit is simply standard pipe that has been carefully reamed inside to remove burrs, and then treated with zinc or an enamel, baked on, to prevent rust. The threads on the lengths of conduit are standard pipe threads.

**60. Wire Used in Conduit.**—The wires used in conduit must be rubber covered. Each conductor must run continuous from outlet to outlet without splices or taps. The same conduit may contain as many as four two-wire or three three-wire circuits if the voltages are the same, but under no circumstances should high-voltage and low-voltage wires be run in the same conduit. Duplex wire is largely used in branch circuits in conduit.

**61. Number of Wires Permitted in Conduit.**—A complete table of the "Sizes of Conduit for the Installation of Wires" is given in the National Electrical Code. We find it permissible to run three No. 14 wires in ½″ conduit or four wires if the length of the conduit is not over 30 ft. and has not more than two quarter bends from outlet to outlet, the bends at the outlet not being counted. Ordinarily, not more than four No. 12 wires should be placed in a ¾″ conduit but five are permitted under the circumstances stated above. Two No. 12 wires require a ¾″ conduit.

**62. Rules Regarding Conduit Runs.**—Conduits containing feeders should run straight and as direct as possible to the outlet or panel. There should never be more than the equivalent of four right-angled bends between drawing outlets. Good electrical contact must be provided between all parts of the conduit system because under certain conditions the conduit must carry current. To have separated parts in a conduit system is dangerous. Conduit systems should be grounded.

**63. Outlet Boxes.**—Outlet boxes used for conduit wiring are usually of sheet steel, coated with zinc or

enamel. They not only hold the conduit ends firmly and form a pocket for enclosing the wire joints, but they constitute electrical connectors between the elements of the conduit system, all of which must be in good electrical contact. Each conduit run must terminate in an accessible outlet box. Outlet plates which are thinner than outlet boxes are used where the installation of outlet boxes is not feasible.

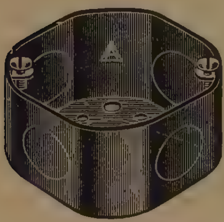


FIG. 26. An octagonal outlet box $3\frac{1}{4}''$ diam., $1\frac{1}{2}''$ deep, and provided with $\frac{1}{2}''$ conduit knock-outs.

**64. Types of Outlet Boxes.**—Conduit outlet boxes are made in a large number of forms, as are also the covers for use with them. In Figs. 26, 27 and 28 are shown various types of boxes, and in Fig. 29 are shown various covers.

For ordinary work, the shallow box and the combination square box are used. The former can be used where it is convenient to enter the conduit from the back. Standard round boxes for installations in brick are about $1\frac{1}{2}''$ deep to $1\frac{5}{8}''$ deep and those for lath and plaster are about $2\frac{1}{4}''$ deep. This depth is necessary to guarantee that the conduits entering the side knock-outs will clear the plaster. Shallow boxes are $\frac{1}{2}''$ to $\frac{3}{4}''$ deep. Boxes are made in $3\frac{1}{4}''$ and $4''$ sizes. For most work the $3\frac{1}{4}''$ size is large enough.

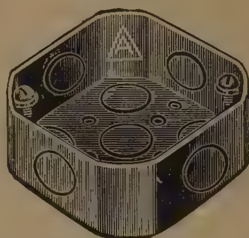


FIG. 27. An octagonal outlet box $4''$ diam., $2\frac{1}{8}''$ deep, $\frac{3}{4}''$ knock-outs.

**65. Problems Involved in Conduit Work.**—Among the many operations involved in the installing of conduit work the following are perhaps most common:

1. Cutting conduit.
2. Threading conduit.
3. Coupling pieces of conduit.
4. Connecting to outlet and switch boxes.
5. Bending conduit.
6. Making horizontal runs.
7. Making vertical runs.
8. Providing for a fixture.
9. Providing for a switch.
10. Providing for a receptacle.
11. Providing for heaters.
12. Grounding conduit systems.

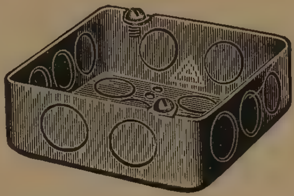


FIG. 28. A 4″ square outlet box.

**66. Cutting Conduit.**—The best tool for cutting conduit is the hack-saw. Pipe cutters leave a large burr with a sharp edge on the inside of the pipe which must

FIG. 29. Various types of covers for octagonal boxes.

be reamed out to avoid abrasion of the covering of the wire when it is drawn thru. Conduit should be held rigidly in a vise while being cut.

**67. Threading Conduit.**—Threads on conduit are similar to those on steam and gas pipe, so ordinary pipe dies are used for cutting them. Don't try to cut threads until you find out how to use the threader in the proper manner. Re-thread all of the ends of the

conduit to insure the removal of enamel or dirt and to make good electrical connection between the parts of the system.

**68. Coupling Pieces of Rigid Conduit.**—When it is necessary to connect two pieces of rigid conduit, a pipe coupling is used. The threads should run far enough so that the ends of the conduit pieces will touch inside the coupling and therefore provide a smooth runway mechanically and electrically secure. It is evident that if a space were left inside the coupling between the two pieces of conduit it would be difficult to push a wire thru because it might get caught in the space and wires are not installed in a conduit system until the installation is complete.

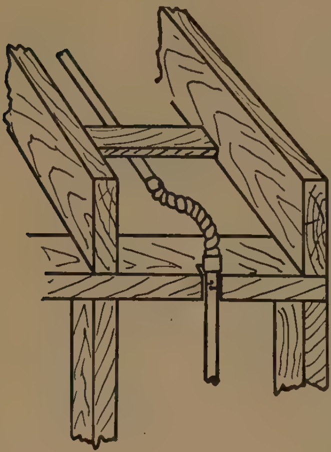


FIG. 30. A sketch showing an application of combined rigid and flexible conduit.

The threads should be cut no farther than to permit the butting of the conduits inside the coupling because the unenameled threads would be exposed to the atmosphere and might rust quite readily.

**69. Coupling Pieces of Rigid and Flexible Conduit.**—Flexible conduit, described later, is often used in connection with rigid conduit as indicated on the sketch shown in Fig. 30. Special couplings are made for this purpose. The manner in which they are used is obvious.

**70. Coupling Pieces of Flexible Conduit.**—Special connectors are available also for connecting pieces of flexible conduit. The same precautions should be taken when making connections of this kind as in the case of coupling pieces of rigid conduit.

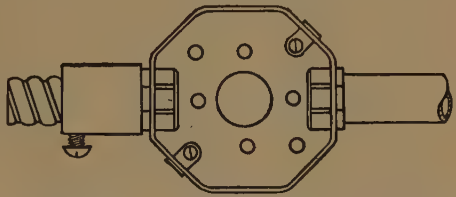


FIG. 31. A sketch showing the manner in which rigid and flexible conduit are connected to outlet boxes.

**71. Connecting to Outlet and Switch Boxes.**—Connections to outlet and switch boxes should be made very carefully. Since all runs of conduit must extend into steel boxes or into outlet fittings, and all parts of the system must be mechanically secure and electrically connected, it is evident that outlet-box connections are important.

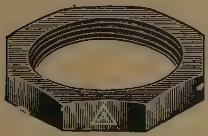


FIG. 32. A steel lock-nut.

In Fig. 31 is shown a sketch of an outlet box to which are connected a piece of rigid conduit and a piece of flexible conduit.

Conduits are secured to the boxes by the use of metallic lock-nuts and bushings and in the case of flexible conduit, by box connectors. In Fig. 32 is shown a lock-nut; in Fig. 33, a bushing; in Fig. 34, one type of straight box connector; and in Fig. 35, one type of 90-degree box connector.

Lock-nuts are used for holding the box squarely to the conduit, and the bushing is used on the end of the conduit to form a neat outlet for the wires. If the conduit extends into the box, two lock-nuts should be

used to do away with the possibility of the shifting of the conduit in the knock-out hole. Lock-nuts are usually furnished with box connectors.

FIG. 33. A cast bushing.

**72. Bending Conduit.**—It is evident that in running conduit circuits, considerable bending of the conduit will be involved. The most common bend, perhaps, is the ninety-degree, or right-angle bend, which is required when a square corner is turned. In Fig. 36 is shown one case in which a bend is required and also a method used in providing for concealed conduit runs.

FIG. 34. A straight box connector for flexible conduit or armored conductors or cable.

To bend conduit correctly and neatly is no easy task. Various improvised methods may be used when only a few bends are to be made such as placing the conduit in a hole in a post, the crotch of a tree, etc., but the most common and easily devised method of bending is by the use of a bending "hickey." For bending ½″ or ¾″ conduit, a hickey can be made by screwing a 1″ pipe tee on the end of a piece of pipe three or four feet long. The tee of the bending hickey is slipped over the pipe to a point within about two inches of the point where the bend is to come and the handle is pulled back until the angle is about one-fourth bent; then, the hickey is moved an inch or so and the conduit is bent some more. This is continued until the bend is completed. The bend, if it is a right-angle bend, may be

FIG. 35. A 90-degree box connector for flexible conduit or armored cable.

tested by placing it within a right angle marked on a floor, or by placing it in a square corner. Commercial benders are available if desired.

**73. Making Horizontal Runs.**—In concealed installations, runs both parallel to and across the joists will be required. When runs are made parallel with the

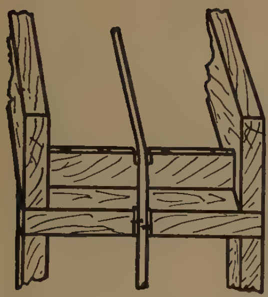


FIG. 36. A sketch showing a conduit run in a concealed installation where a bend is required. Also methods of supporting conduit.

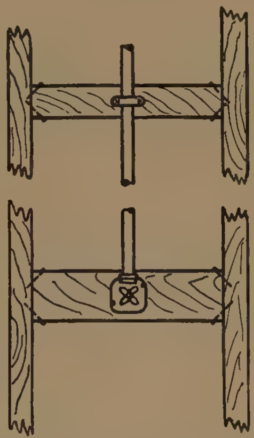


FIG. 37. A sketch showing a run of rigid conduit terminating in an outlet box.

joists, the conduit and outlet boxes are usually supported on wooden cleats placed so as to bring the front edge of the boxes not more than ¼″ back of the finished surface of the plaster. See Fig. 37. On wooden walls or ceilings, outlet boxes must be placed so that the front edge will either be flush with the finished surface or project from it.

Some times conduit can be attached to the under part of the floor above and suitable bends be made to bring the outlet boxes in the right place.

Horizontal runs across the joists are provided for by boring holes or slotting them. In some cases slotting is not permitted. When slots are made they should be as narrow and shallow as will admit the conduit. Each slot is made by making two saw cuts in the joist and then gouging out the little block with a chisel. After the conduit is in place it is usually secured by driving nails into the joists and bending them over it. See Fig. 36.

FIG. 38. A pipe strap commonly used for attaching conduit.

**74. Making Vertical Runs.**—Vertical runs of conduit are usually supported on wooden cleats inserted between the studs or between the joists at the top of the run as indicated in Fig 36. Pipe straps such as shown in Fig. 38 are used for attaching conduit to wooden cleats or to wooden surfaces. These are used also for exposed construction. When used on brick walls, they are often screwed to wooden plugs driven into holes in the wall. These holes are usually drilled into the wall with what is known as a star drill.

FIG. 39. A fixture stem, or stud, for use in supporting fixtures.

**75. Providing for a Fixture.**—Providing for a fixture involves the selecting of a suitable outlet box, the locating of the box in the proper place and in a manner such that its front edge will be flush with, or not more than ¼″ back of the finished surface of the wall, and the attaching of the fixture stud, or stem.

The outlet box may be supported on a wooden cleat. The fixture stud, see Fig. 39, is used for supporting

the fixture, and is attached to the bottom of the outlet box with small bolts. When the fixture is installed, an insulating joint is placed so the fixture will be entirely insulated from the outlet box. These insulating joints should be interposed in the stem of all electric fixtures as near as possible to the ceiling or walls. The reason for this is that there is always a possibility that contact may be made between the metal of a fixture wire and the metal parts of the fixture. If this should happen in a fixture not insulated from the conduit system, the contact with the fixture would cause connection to the whole system while in an insulated fixture the connection would be only within the fixture itself.

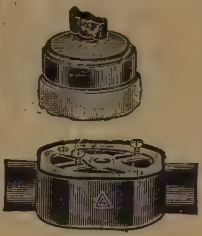


FIG. 40. A conduit arrangement providing for a snap switch.

**76. Providing for a Switch.**—Providing for a switch requires the locating of the switch-box in the desired position. For wiring in finished buildings, boxes with ears similar to those required for knob-and-tube work are commonly used. Fig. 40 shows a method of providing for a snap switch. This is only a typical example, however, there being other types of fittings available. The type of fitting shown is commonly known as an "octagonal unilet." It is especially suited for exposed work.

**77. Providing for a Receptacle.**—Flush receptacles are provided for by installing a box as for flush switches, or by the use of special fittings when the work is exposed, as is often the case in the basement. An arrangement of the latter type is shown in Fig. 41.

**78. Providing for a Heater.**—Because of the danger involved in the use of heaters, especially electric flat-irons in basement laundries, it is well to provide a safe arrangement for such appliances. Many fires have been caused by the overheating of a flat-iron accidentally left without turning off the current. The arrangement shown in Fig. 42 is very satisfactory for a flat-iron and the possibility of trouble of this kind is eliminated. The receptacle into which the extension-cord plug is inserted is mounted over the opening on the lower part of the fitting. The large opening is for the mounting of a flush switch. The receptacle on the top is provided for a lamp which is so connected that it lights up whenever the current is flowing thru the heater. The advantages of this arrangement are obvious. Several different types of fittings of this kind are available. In Fig. 43 is shown one that is suitable for use with a snap switch mounted over the lower opening. The receptacle for attaching the heater is placed on the end of the fitting and provision is made within the fitting for the pilot lamp which shows thru the red glass. Space is also provided for a cut-out within the fitting so that the fuses are conveniently located.

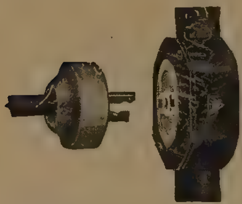


Fig. 41. A conduit arrangement providing a plug receptacle.

**79. Grounding Conduit Systems.**—Interior conduits must have the metal of the conduit permanently and effectively grounded to water piping, gas piping, or other suitable grounds, provided that, when the connection is made to gas piping, it is made on the street

side of the meter. Permanently grounding conduit decreases fire hazard and may also decrease life hazard.


FIG. 42. A conduit fitting providing for the attachment and control of heating devices, where a flush switch is to be used.

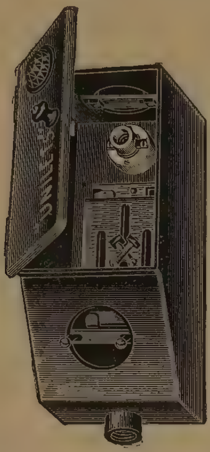


FIG. 43. A conduit fitting providing for the attachment and control of heating devices where a snap switch and cut-out are to be used.

The connections to the pipes are usually made by the use of ground clamps and the wire for grounding should be not smaller than No. 10 B & S gage copper wire.

**80. Flexible Conduit.**—As has already been intimated, flexible conduit is suitable for use where it is difficult to make suitable bends in rigid conduit. This is especially adapted to work in finished houses where the installing of rigid conduit would be practically impossible. A sketch of a piece of flexible conduit is shown in Fig. 44.

**81. Armored Cable Work.**—Armored cable has a covering on it similar to flexible conduit. The wires

are not removable, however. It is obvious that cable of this kind is exceedingly desirable for use in wiring houses, especially where there are a great many circuits which necessitate the running of large numbers of wires near each other; and in wiring old houses.

FIG. 44. A sketch of a piece of flexible steel conduit.

FIG. 45. A sketch of pieces of B. X. L. and B. X. armored conductors, or cable, the B. X. L. having a lead covering in addition to the steel.

The cable is made in two different forms commonly called B. X. and B. X. L. The B. X. has the steel covering while the B. X. L. has, in addition to the steel, a lead covering which makes it especially adapted to uses in damp places. Sketches of B. X. and B. X. L. cable are shown in Fig. 45.

**82. Rules for Armored Cable Work.**—Armored cable must be continuous from outlet to outlet or to boxes or cabinets, and the armor of the cable must properly enter and be secured to all fittings, and the entire system must be mechanically secured in position. Couplings cannot be used in armored cable work. Armored cables are attached to outlet boxes by means of special connectors similar to those used with flexible conduit. Outlet boxes or plates must be provided at every outlet as required in conduit work. In finished houses

where it is impossible to use either outlet box or plate, these may be omitted by special permission. All parts of an armored cable installation must be permanently and effectively grounded.

## Summary of Chapter V

1. As a general proposition, rigid conduit wiring should be used wherever the job will stand the cost.

2. Rigid conduit is simply standard pipe that has been carefully reamed inside, and then treated with zinc or enamel, baked on, to prevent rust.

3. Rubber-covered wire must be used in conduit.

4. Only certain numbers of wires of a given size are permissible in a conduit.

5. A conduit run should not contain more than four right-angle bends.

6. Outlet boxes of various types and sizes are available for use with conduit.

7. Conduit should be cut with a hack-saw.

8. Conduit is threaded with standard pipe threads.

9. Good electrical connection must be made between all parts of a conduit system.

10. All parts of a conduit system should provide a smooth run-way for the wires.

11. Lock-nuts and bushings are used for connecting to outlet boxes.

12. Conduit may be bent by the use of a bending "hickey."

13. Outlets in a conduit system are provided with suitable metal boxes.

14. Various special fittings are available for heaters.

15. All conduit systems must be grounded.

16. Flexible conduit is especially desirable for use in finished houses.

17. Armored cable is similar to flexible conduit but the wires are not removable.

18. The rules for armored cable work are similar to those for rigid and flexible conduit.

19. In conduit and armored cable installations, the fixtures should be insulated.

## Questions

1. What is rigid conduit?
2. How does the cost compare with other methods?
3. What advantages are brought about by its use?
4. What kind of wire should be used in conduit?
5. How many No. 14 wires are permitted in a ½-inch conduit?
6. What are the rules relative to conduit runs?
7. What are outlet boxes?
8. How deep are boxes commonly used for lath and plaster?
9. Why is this depth necessary?
10. List ten or more operations involved in installing conduit work.
11. How should conduit be cut?
12. How is conduit threaded?
13. How may two pieces of rigid conduit be coupled?
14. How may a piece of flexible conduit be connected to a piece of rigid conduit?
15. How may two pieces of flexible conduit be connected?
16. How are connections made to outlet boxes?
17. How is it possible to bend rigid conduit?
18. Describe a method of supporting conduit runs.
19. How are vertical runs of conduit commonly supported?
20. How may outlet boxes be supported?
21. What arrangement is made for supporting fixtures?
22. Why should insulating joints be interposed in the stem of all electric fixtures?
23. How may provision be made for a switch or receptacle?
24. Describe a special heater fitting and give the advantages brought about by its use.
25. Why must conduit systems be grounded?
26. For what type of work is flexible conduit adapted?
27. What is armored cable?
28. What are the rules relative to armored cable installations?

# CHAPTER VI

## Installations in Finished Buildings

**83. Work Involved.**—The work involved in the wiring of a finished building in addition to that in wiring one while under construction is more difficult in many ways. This is because of the necessity of removing floor boards, replacing floor boards, removing trim, cutting holes in plastered surfaces, and the running wires or conduits under floors and between walls.

**84. Why This Phase of the Work Is Important.**—Because of the fact that many homes are at present not provided with electrical conveniences, and because of the fact that many installations have not been properly planned or have not been made extensive enough to provide for new electrical appliances, it is quite necessary that everyone be somewhat familiar with the manner in which installations can be made in finished houses. The purpose of the information that follows is to give brief descriptions of a few of the more important operations and requirements in addition to those involved in the wiring of new houses. The arrangements will, of course, be as nearly as possible the same as they would have been had the house been wired while under construction, and for general information, discussions of installations in new houses should be referred to.

**85. Knob-and-Tube Work in a Finished House.**—In making a knob-and-tube installation in a finished house it is necessary to remove sufficient floor boards and

trim to make possible the running of the wires under floors and between walls. Where it is not possible to support the wires on knobs at intervals not to exceed four and one-half feet, as is often the case in making runs to switches and receptacles, loom must be used the full length of the wires from the last knob to the outlet. This may be necessary in other cases, also where it is desirable to cut small pockets in the floor. It is often possible, however, to make the runs in the basement or the attic and reduce the removing of floors to a minimum or perhaps eliminate it entirely. This is one of the chief differences in the actual installation of the wires from that in a house under construction.

The knob-and-tube method is one often applied in the wiring of finished houses. It is not permitted in some localities, however.

**86. Armored Cable Work in a Finished House.**—Steel-armored cable is a good material to place in frame buildings because it can be drawn quite easily under flooring and into partitions.

**87. Flexible Steel Conduit in a Finished House.**—Flexible steel conduit is also a good material for use in the wiring of finished frame buildings because it, too, can be drawn easily under floors and between partitions.

**88. Rigid Conduit in a Finished House.**—It is more difficult to install concealed rigid conduit in a finished house than any other material and more cutting is usually required. This is obvious. Combinations of rigid and flexible conduit may be used with quite a degree of success, however. Rigid conduit is not gen-

erally used for concealed work unless the building is undergoing reconstruction.

**89. Removing Floor Boards.**—When it is necessary to remove floor boards a sharp, thin chisel should be used to start the cut at a point at the edge of a board and near a joist. Then the required cuts should be made with a keyhole saw. The saw cut should extend thruout the complete length of the board to be removed to avoid the splitting of the adjacent board into which the tongue extends, or the grooved side of the board may be raised with a wide chisel in which case the grooved portion of the board is broken off on the under side. The latter makes a neater job if a wide, thin chisel is used. In many cases it is sufficient to simply remove a pocket of sufficient size to permit the fishing of the wires and the supporting of the wires properly at the outlet to which they lead.

**90. Replacing Floor Boards.**—When the floor boards are replaced after the installation has been completed, cleats should be nailed onto the sides of the joists to provide ample support at the ends where the cuts have been made. The need of these is obvious.

**91. Removing Trim.**—Unless care is used in removing baseboards, they are liable to be split and a neat job is practically impossible. No attempt should be made to pull the nails out or to drive out any of those which remain in the trim after it has been removed. They should be driven in with a fine nail set before the trim is removed and those remaining in the trim should be cut off. The nail heads are usually driven into the boards slightly and the holes filled when the trim is

put into place. An attempt to drive the nails out usually causes the splitting of the board.

**92. Cutting Holes in Plastered Surfaces.**—Before cutting holes in plastered surfaces, one should determine the exact size of the plate, or base, of the switch or receptacle to be installed or the size of the canopy or ceiling attachment of a fixture to be used. The plates for switches and flush receptacles are usually only about $\frac{1}{4}''$ larger than the hole required for the box into which they are to be placed and in some cases, especially where a rosette is used in connection with a drop cord, only a small space is covered on the ceiling.

Before the holes are marked out, the position of the joists or studs near their location should be determined by probing thru the plaster with a small sharp screwdriver. If one should strike a joist or a stud when cutting a hole in the ceiling or wall he would find it very difficult to make the necessary opening for a box and he can not change the position of the hole after it has been started.

After having located a space in which there is no possibility of striking a joist or stud, it is well to place the box on the wall or ceiling and to mark around it. Then the hole should be cut just a little larger than the space marked to permit the fitting of the box into the opening made. These marks may be made with a sharp screwdriver which will cut thru the wall paper and into the plaster and make the removing of the plaster more readily accomplished. The plaster is then carefully removed with a chisel and the hole is cut.

Where a box for a fixture is being provided, it is necessary to remove the lath only where the conductors pass into the openings in the bottom of the box, but where provision is made for a switch or a flush receptacle the full space required by the box must be provided.

It is often convenient to bore several holes in the wall where the opening is to be made to make possible the insertion of the keyhole saw blade. It is best not to cut the lath entirely across at once but to cut first on one side of the opening and then on the other until the piece of lath is removed. This assists in avoiding the breaking of the plaster by a short length of lath.

**93. Drawing Wires Into Outlets.**—In wiring finished buildings it is obvious that considerable "fishing" will be required to get the wires to the desired places. There are several methods and devices for doing this, but in spite of these considerable difficulty is often encountered. Only a few helpful points will be mentioned here.

A good "mouse" can be made by the use of a lead sinker or a piece of solder wire bent into the proper shape and attached to the end of a strong cord. Sometimes a piece of small chain may be used advantageously. When two wires are to be drawn to the same outlet, as is usually the case, it is best, if possible, to pull both at the same time. In case they must be covered with loom, it is well to have the loom on them. The stiffness of the loom assists in pushing the wires in desired directions and it is difficult to place it on conductors after they have been drawn into place. This is especially true in runs between partitions.

**94. Other Methods Sometimes Used.**—In addition to the methods of wiring suggested in the foregoing, there are several others that may be used in some particular cases where additions must be made to installations, where the work must be exceedingly inexpensive, or where other considerations are of importance. These methods are applied more extensively in store, factory, or other installations outside of the home and are taken up in a brief way only in this book because of this. Among these methods are the running of wires in metal molding, the running of wires in wooden molding, and the supporting of wires on knobs and cleats.

**95. Metal Molding Work.**—Metal molding, and the various fittings which make possible practically every type of arrangement desirable, is obtainable in various forms. When it is necessary to install exposed work, this molding is better than any other.

The installation of the molding for a simple installation or addition is not difficult for one familiar with the other methods of wiring. However, the following points should be remembered in connection with work of this kind: 1. The molding must be continuous from outlet to outlet. 2. Proper fittings must be used thruout the installation. 3. The wires must be laid in the molding and not pulled thru it. 4. Metal molding must be permanently grounded.

**96. Wooden Molding.**—The use of wooden molding is prohibited in many places, but it is still used in some cases. It may be useful in providing an extension to some existing installation. The application of molding of this kind is largely an assembly of parts

which is ordinarily quite easy for one experienced in other types of wiring.

**97. Knob and Cleat Work.**—Under certain circumstances it may be possible to support exposed runs of wire on knobs and cleats. If this is desirable, it should be remembered that a line of this kind must be supported by knobs or cleats at points not more than four and one-half feet apart and not over 12″ from a dead end.

For cleat work of various kinds, cleat receptacles are used, as are also bases of suitable design to hold the wires properly. The use of cleat receptacles is not limited to that in connection with cleat work, however. Receptacles of this type are often used in porch fixtures and in basements.

### Summary of Chapter VI

1. Wiring a finished house involves, in addition to the work in a house under construction, the removing of floor boards, the removing of trim, cutting holes in plastered surfaces, and running wires or conduits under floors and between walls.

2. This work is important because many houses are not yet wired and in many others changes and additions are desirable.

3. Knob-and-tube, flexible conduit, and armored cable installations are well adapted for use in finished houses.

4. Rigid conduit is not generally used in concealed work unless the building is undergoing construction.

5. Floor boards can be removed by means of a sharp thin chisel and a keyhole saw.

6. When floor boards are replaced they may be supported by small cleats nailed to the joists.

7. Nails should be driven into trim with a fine nail set; not driven out.

8. The studs or joists near an opening should be located before the hole is started in a wall or ceiling.

9. A "mouse" can be made by the use of a lead sinker or a piece of solder wire attached to the end of a strong cord.

10. The loom should be placed on wires before they are drawn into an outlet.

11. Metal molding, wooden molding, or knob and cleat work may be advisable in some cases where the wiring cannot be concealed.

## Questions

1. What work involved must be taken into consideration in wiring of finished house, in addition to that in a new house?

2. Why is the wiring of finished houses important?

3. What methods of wiring are suitable for installations in finished houses?

4. How can floor boards be removed?

5. How can floor boards be supported when they are put back into place?

6. How should trim be removed?

7. What precautions should be taken when cutting holes in plastered surfaces?

8. How can wires be drawn into outlets?

9. How can a suitable "mouse" be made?

10. What methods of exposed wiring may be used in some cases where concealed work is impractical?

# INDEX